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ELECTRONICS AND ELECTRICAL ENGINEERING

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USSR REPORT

ELECTRONICS AND ELECTRICAL ENGINEERING

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UDC 621.365.5:548.55

INDUCTION SYSTEMS FOR ELECTROMAGNETIC SHAPING OF SILICON CRYSTAL DURING GROWTH

Moscow ELEKTROTEKHNIKA in Russian No 2, Feb 83 (manuscript received 25 Dec 81)
pp 52-54

LEV, L. R., engineer, All-Union Scientific Research Institute of High-Frequency Currents imeni V. P. Vologain (VNIITVCh)

[Abstract] Electromagnetic shaping of silicon crystals during their growth is a modification of inductive contactless forming of rods and tubes directly from the melt on a pedestal without crucible. The basic two problems in designing the electromagnetic system with an inductor for this application are:
1) To configure its structure for producing crystals of a given shape; and
2) To maximize the electrodynamic action with minimum thermal effects. The optimum frequencies for producing silicon wafers and ribbons of various thicknesses and widths have been determined theoretically and verified experimentally, a larger crystal thickness or width requiring a lower frequency. Experiments were performed with the "Kristall" high-frequency apparatus for vertical zone refining at its nominal frequencies of 5.3 and 2.5 MHz, but 1.76 MHz has been finally selected as the standard frequency for pulling silicon rods. In order to produce a desired crystal profile, it is necessary to control the crystallization front by regulating the heater power as well as the air gap between inductor and pedestal. Stability and repeatability of the pulling process are attained by providing favorable capillary action, the crystal cross section depending on the angle between the vertical crystal surface and the tangent to the free surface of the melt. The maximum attainable growth rate is 20 mm/min for crystals 5-6 mm in diameter. References 4: 3 Russian, 1 Western.
[190-2415]

ELECTRON DEVICES

UDC [621.3.038.613:537.533].032.213.2

THERMOEMISSION CATHODE OF HIGH-VOLTAGE HIGH-CURRENT ELECTRON INJECTOR

Moscow ELEKTROTEKHNIKA in Russian No 2, Feb 83 (manuscript received 25 Jun 82)
pp 59-60

BATRAK, I. K., engineer, ZAV'YALOV, M. A., candidate of technical sciences, LOGINOV, L. V., candidate of technical sciences, POZDNOV, V. I., engineer, POKROVSKIY, S. V., candidate of technical sciences, TARASENKOV, V. A., engineer, TSKHAY, V. N., engineer, and CHUPROV, V. N., engineer, All-Union Order of Lenin and Order of the October Revolution Institute of Electrical Engineering imeni V. I. Lenin (VEI)

[Abstract] A thermoemission cathode used in high-voltage pulse-type electron injectors is heated by an electron flux generated by an auxiliary electron gun. Formation of a high-current electron beam requires uniform heating of this cathode. An experimental system has been designed for a large thermoemission cathode of an electron injector generating a beam of 500 keV electrons in pulses of 250 microsecond duration. The cathode is spherical, 15 cm in diameter, made of a molybdenum core-substrate heated by the electron flux on the convex side and coated, by plasma sputtering, with an LaB_6 emitter film on the concave side. It is placed inside a vacuum chamber, mounted on a flange of stainless steel for minimization of heat losses by conduction and compensation of thermal strains. This ensures that its position in the plane of the focusing electrode and coaxiality with the latter is maintained during operation. The auxiliary electron gun generates a 100 kW beam of 30 keV electrons with a power density of 10^5 W/cm^2 for heating the thermoemission cathode to approximately 1650°C . This beam is swept over the surface of the cathode in concentric circles at a frequency of 500 Hz, driven by a coil with analog-digital control on a microcircuit chip. The cathode of the electron gun is 1.2 cm in diameter and made of tantalum, heated by electron bombardment with a power of 500 W. The entire device was tested under a vacuum of $1 \cdot 10^{-5}$ – $1 \cdot 10^{-4}$ torr, the temperature of the cathode (emitter and core) as well as its radial profile being measured through a window with a pyrometer at various levels of heating power. Temperature cycling and vacuum cycling degraded neither the physical properties nor the mechanical stability of the emitter film. Its integral emissivity of 0.82–0.85 exceeds by far that of the surface of molded cathodes. Figures 2; references: 4 Russian.
[190-2415]

UDC 621.311.4.019.3:621.311.153.001.24

NECESSARY ACCURACY OF METHODS USED FOR CALCULATING ELECTRIC LOADS AND
ESTIMATING RELIABILITY OF ELECTRIC POWER SUPPLIES IN INDUSTRIAL ENTERPRISES

Novocherkassk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ELEKTROMEKHANIKA in
Russian No 12, Dec 82 (manuscript received 29 May 81) pp 1448-1451

KUDRIN, BORIS IVANOVICH, candidate of technical sciences, and
LOSEV, EDUARD ANATOL'YEVICH, candidate of technical sciences,
acting professor at Northwestern Correspondence Polytechnical Institute

[Abstract] Simpler methods of calculating the electric loads and estimating the reliability of electric power supplies in industrial enterprises can be more accurate than complex methods often burdened with insufficient data and involving needless refinements. This assertion is based on a study of CEMA enterprises which the All-Union Scientific Research and Design Institute of Electrical Installations made during the nineteen seventies. As a result of this study, criteria of necessary and sufficient accuracy have been established for mathematical models describing a given technological process. The errors of load calculations depend on the complexity (multiparametricity) of the algorithm, decreasing as the number of parameters becomes smaller, and on the principle according to which loads at the upper hierarchical level are calculated from data at the lower level. The reliability of power supplies has been more often overestimated than underestimated. The proper criterion for sufficient accuracy is commensurability of errors in the input data and errors in the results of calculation when two similarly accurate variants of a model are used. The criterion of necessary accuracy is matching a model and methods of its estimation with the volume of available information about the object. References: 12 Russian.
[154-2415]

INSTRUMENTATION & MEASUREMENTS

INSTRUMENTS AND SENSORS FOR ESTIMATING INTENSITY OF COOLING

Kiev TEKHNICHESKAYA ELEKTRODINAMIKA in Russian No 6, Nov-Dec 82 pp 9-10

BUT, A. A.

[Abstract] A brief description is given of the IT-2M instruments with convective heat transfer and heat flow sensors developed at the Special Technological Design Bureau of the Institute of Electrodynamics in conjunction with associates of the institute, for the purpose of experimental estimation of the intensity of cooling of electrical machines, air-cooled internal combustion engines and the like. The heat flow sensor is a film-type battery element whose thermo-emf is proportional to the heat flow passing through its surface. Heat flow sensors are furnished with a film-type heating element and two thermocouples, one for the sensor's surface and one for the heat transferring surface, in order to increase measurement accuracy under conditions of convective cooling of the heat transferring surface. Sensors can be created for measuring heat flow from 10 to 10^4 W/m² with various sensitivities. Convective heat transfer coefficients can be measured in the range of 10 to

$5 \cdot 10^3$ W/m² · °K by means of sensors designed on the basis of heat flow sensors with the addition of a thermocouple for the environment. The sensors described can operate in air, hydrogen, oil and water with temperatures from 283 to 373°K. The sensors have the appearance of streamlined plates measuring 32 x 20 mm and not less than 1 mm thick. The IT-2M instrument with which these sensors are used has a built-in type F217 1/10 milliammeter for testing and measuring the current in the sensor's heating element. Responses of the battery elements and thermocouples are recorded by means of a type FZO millivoltmeter controlled manually, and an automated system for recording data on a printer. The equipment described can be used for studying the intensity of heat transfer in gas- and liquid-cooled equipment. Figures 1.

[131-8831]

MAGNETICS

UDC 621.313:537.312.62

ELECTRODYNAMIC TRANSIENT PROCESSES IN ELECTRIC MACHINE SUPERCONDUCTING MAGNETIC SYSTEM

Moscow ELEKTRICHESTVO in Russian No 3, Mar 83 (manuscript received 7 Jul 82)
pp 69-71

DAN'KO, V. G., doctor of technical sciences, YANTOVSKIY, L. I., candidate of
technical sciences, MIROSHNICHENKO, A. G., BERZIN, YE. K., engineers, Kharkov

[Abstract] This article outlines a method for calculating transient magnetic field excitation and damping processes in the multipole super-conducting magnetic system of an electric machine. An explicit pole magnetic system with multilayer ferromagnetic core is analyzed. It is found that planning of super-conducting magnetic systems must include consideration of the effect of transient currents in cryostatic structural elements. The results of the calculations show that the greatest transient currents arise when the field is damped in a copper heat shield. Calculation of the electromagnetic forces acting on the heat shield upon damping of the field shows that these conditions may be dangerous. Figures 2.

[202-6508]

UDC 535.4

DETERMINATION OF LAYER THICKNESS IN LOCAL EPITAXIAL STRUCTURES

Moscow MIKROELEKTRONIKA in Russian Vol 12, No 1, Jan-Feb 83
(manuscript received 23 Nov 81) pp 70-75

BILENKO, D. I., KAZANOVA, N. P. and POLYANSKAYA, V. P.

[Abstract] There are no practical methods available for determining the thickness of local formation in epitaxial structures. Because micro-electronic multilayer structures can be regarded as reflection-diffraction amplitude-phase gratings, consideration is given to the feasibility of using the ellipsometric method for determining the thickness of a protective coating and the step height between such a coating and a local epitaxial formation. The principle of such a measurement is based on the approximate, but sufficiently accurate, description of the diffraction field in the Fraunhofer zone by the complex scalar wave function in accordance with the Kirchhoff-Huygens theory. Two ellipsometric parameters, namely the ratio of and the phase difference between the amplitudinal reflection coefficients for light polarized, respectively, parallel and perpendicularly to the plane of incidence, both depend on the thickness of the protective coating and the height of the step it forms above the bare surface. They also depend on the optical properties of the coating material. The corresponding ellipsometric equation has been solved graphically, an analytical solution not being possible, for a silicon structure with a periodic array of SiO_2 -coated regions and local bare Si formations. Actual measurements by this method are checked against independent measurements of coating thickness and step height by etching and with a profilometer, the results indicating that diffraction ellipsometry is sufficiently accurate. Figures 2; tables 2; references 9: 5 Russian, 4 Western (2 in translation).
[191-2415]

UDC 539.23:621.315.63

PHYSICO-MATHEMATICAL MODEL OF DEPOSITION PROCESS FOR POLYCRYSTALLINE SILICON FILM IN HORIZONTAL LOW-PRESSURE REACTOR

Moscow MIKROELEKTRONIKA in Russian Vol 12, No 1, Jan-Feb 83
(manuscript received 10 Nov 81) pp 17-23

KOBKA, V. G., MEDVEDEV, Yu. P. and USHANKIN, Yu. V.

[Abstract] Pyrolytic deposition of polycrystalline silicon films from silane in the gaseous phase under low pressure has been studied experimentally, but so

far no satisfactory theoretical interpretation of the results has been given. Here a physico-mathematical model of the process is constructed from isothermal deposition in a horizontal low-pressure reactor with a 96% Ar+ 4% SiH₄ reactant mixture. Production of silicon is assumed to be a heterogeneous chemical reaction accompanied by adsorption-desorption of reactant and product molecules, with the reaction in the gaseous phase disregarded. SiH₄ molecules are transported by the stream through the reactor and a Si film deposited on the reactor walls by diffusion. An analysis of the process kinetics covers two ranges of SiH₄ partial pressure: 1) Linear adsorption with very low surface coverage and the reaction (deposition) rate proportional to the molecule concentration; and 2) Strong effect of adsorption with full surface coverage and the reaction (deposition) rate depending intricately on the total pressure. The radial profile of the deposition rate is calculated from the two-dimensional steady-state equation of diffusion with appropriate boundary conditions for plane-parallel silicon disks in the reactor. The distribution of the reaction rate over the isothermal zone is calculated from the solution to that equation in series form, taking into account SiH₄ depletion of the stream within the linear range and taking into account the adsorption layer within the nonlinear range. Experimental results obtained in a reactor with silicon disks 60 mm in diameter and 2.1 mm apart, agree closely with this theory and reveal the transition from linear to nonlinear range. The process parameters in the experiment were: temperature T = 630°C, rate of reactant mixture flow L = 180 lit/h, radius of disks R = 47 mm. The deposition rate was measured with a "Libror Micro" analytical balance. The authors thank S. M. Repinskiy for discussion and helpful comments. Figures 5; references 12: 6 Russian, 6 Western (2 in translation).
[191-2415]

UDC 621.315.592

INITIAL (FIELD-INDUCED) BREAKDOWN AND DEFECTS IN DIELECTRIC OF MOS-STRUCTURES ON SILICON

Moscow MIKROELEKTRONIKA in Russian Vol 12, No 1, Jan-Feb 83
(manuscript received 3 Mar 81) pp 24-28

DEMIDOVA, G. N., GAVRILIN, N. I. GLUDKIN, O. P. and KOROVIN, S. K., Moscow
Institute of Aviation Technology

[Abstract] Initial breakdown in SiO₂ of MOS structure is analyzed, this breakdown being responsible for the principal failures of field-effect devices. The region of maximum leakage current is assumed to be the most likely site of this breakdown. The dependence of breakdown voltage on leakage current has been established, accordingly, on the basis of a correlation between directly measured breakdown voltage and voltages corresponding to certain current levels (10⁻⁷-10⁻⁴ A/cm²) and a correlation between breakdown voltage and current level at some constant field intensity 5-10% below breakdown level. The voltage of transition to the negative-impedance range on the current-voltage characteristic was regarded as the voltage of initial breakdown and measured with a digital peak voltmeter. Measurements were made in the enhancement mode, using

a MOS structure built on KEF 4.5 and KDB 7.5 silicon single crystals with (100) orientation. Silicon oxide was produced at 1050°C by simultaneous oxidation of all wafers in dry oxygen with CCl_3 admixture, its thickness built up to 1220 and 1140 Å on n-Si and on p-Si respectively. A polycrystalline silicon gate of 0.6-0.8 μm thickness was deposited by the vacuum-dynamic process, with subsequent phosphorus ion implantation and dispersal for prevention of any self-curing of defects. The results reveal a linear dependence of $-\log P$ (P-fraction of specimens not broken down) on the specimen area, from which the field intensity distribution functions for competing breakdown mechanisms can be determined, and a dependence of the breakdown voltage on the defect concentration in $\text{n}^+\text{-Si}(\text{polycrystalline})/\text{SiO}_2/\text{n-Si}$ (single crystal) and $\text{n}^+\text{-Si}(\text{polycrystalline})/\text{SiO}_2/\text{p-Si}(\text{single crystal})$ structures. Injection of electrons from the substrate reveals one kind of defect with Boltzmann distribution statistics in the oxide of $\text{n}^+\text{-Si}/\text{SiO}_2/\text{n-Si}$ structures. The results also indicate an absence of correlation between excess current and field intensity at initial breakdown in $\text{n}^+\text{-Si}/\text{SiO}_2/\text{p-Si}$ structures. Figures 5; tables 2; references 11: 4 Russian, 7 Western (1 in translation).
[191-2415]

UDC 621.383

PHOTOELECTRICAL PROPERTIES OF JUNCTION FORMED BY LIQUID CRYSTAL AND SILICON

Moscow MIKROELEKTRONIKA in Russian Vol 12, No 1, Jan-Feb 83
(manuscript received 13 Nov 81) pp 76-78

BUDAGOV, K. M., ALIYEV, D. F. and KYAZYM-ZADE, A. G., Azerbaijan State University

[Abstract] A study was made of the photoelectrical properties of junctions formed by nematic liquid crystals and n-type silicon. The experiments were performed with n-Si single crystals ($n \sim 10^{16} \text{ cm}^{-3}$) after chemical surface treatment and liquid crystals of p-ethoxybenzyliden-p-butylaniline + p-methoxybenzyliden-p-butylaniline. Ohmic contact tabs were mounted for measurements, metallic In on the Si side and transparent SnO_2 layers on the l.c. side. The magnitude of the photoelectric effect has been found to depend on the orientation of l.c. molecules. The current-voltage characteristic reveals a weak rectification, which indicates formation of a Schottky barrier at the Si-l.c. interface, conduction corresponding to a positive potential on the l.c. side. The diode photo-emf is proportional to the intensity of light illuminating the liquid crystal, its relaxation after turn-off occurring exponentially within 10^{-4} s. The spectral distribution of the diode photo-emf, measured using a sandwich structure (with glass, SiO_2 , and tellurium) conforms with absorption spectrum of n-Si single crystals with the 1.12 eV energy at the red edge approximately equal to the width of the forbidden band in Si single crystals at 300 K. The large photo-emf and the deep bands of intrinsic absorption indicate a high degree of perfection of the interphase boundary. Figures 2; references 9: 7 Russian, 2 Western.
[191-2415]

PHOTOELECTRICAL PROPERTIES OF HETEROJUNCTION FORMED BY PHOTOCONDUCTOR AND THERMOCHROMATIC LAYER IN CdSe-VO_2 RECORDING MEDIUM

Moscow MIKROELEKTRONIKA in Russian Vol 12, No 1, Jan-Feb 83
(manuscript received 24 Aug 81) pp 84-86

KATS, N. B., KUZNETSOV, V. A., LANSKAYA, T. G., MATASOVA, L. P., ROKAKH, A. G. and STARCHAYEVA, Ye. Ye., Saratov Scientific Research Institute of Mechanics and Physics

[Abstract] An experimental study was made of the photoelectrical properties of an In_2O_3 - CdSe-VO_2 "sandwich" film heterostructure. The contact layer, an In_2O_3 film transparent to visible and near-infrared radiation, was deposited on a thin glass substrate by the reactive cathode sputtering process. The photoconducting CdSe layer was deposited by the vacuum evaporation process in a quasi-closed pool. The thermochromatic VO_2 film was produced by first depositing a vanadium film by the vacuum evaporation process and then oxidizing this film in air. A thin indium film served as contact tab. Measurements of the current-voltage characteristics and the current-illuminance characteristics revealed the former to be almost linear and the latter to be superlinear with a saturation range. The temperature dependence of short-circuit current and open-circuit voltage, also the photo-emf spectrum, were measured over the 293-353 K range subtending the transition of VO_2 from semiconductor phase to metallic phase with attendant change of color. The maximum photo-emf decreases and shifts to longer waves (from 680 to 840 nm) as the temperature rises. A shift of the spectrum from the region of positive voltages to the region of negative ones also occurs, this shift beginning at 302 K and becoming complete at 322 K, while the peak at 680 nm gradually vanishes and the spectrum becomes narrower. Hysteresis effects were found to occur during temperature cycling. In addition the capacitance-voltage and resistance-voltage characteristics were also measured. The results indicate that such a structure can be used as light amplifier or image converter for holographic recording. Figures 4; references 7: 6 Russian, 1 Western (in translation).
[191-2415]

UDC 621.383.029.71/73

EXPERIMENTAL STUDY OF PHOTO-EMF IN InSb MOS-STRUCTURES

Moscow MIKROELEKTRONIKA in Russian Vol 12, No 1, Jan-Feb 83
(manuscript received 28 Sep 81) pp 80-83

DAVYDOV, V. N., PETROV, A. S. and USHERENKO, A. A.

[Abstract] An experimental study was made of relaxation processes and of recombination of excess carriers in anodized InSb . The steady-state photo-emf was measured as a function of a constant or slowly varying voltage applied to an InSb MOS structure, of the frequency of light-beam modulation, and of the substrate temperature. Specimens of n- InSb single crystals ($n = 2 \cdot 10^{14} \text{ cm}^{-3}$)

with a [211] orientation were used for the experiment, after galvanostatic electrochemical oxidation of their surfaces with a solution of orthophosphoric acid in ethylene glycol. The anodic oxide film thus produced was 0.1 micron thick, allowing not more than 10^{-12} A/cm² current leakage. Two nickel electrodes, a basic one and a transparent one, were deposited by the vacuum evaporation process. A light-emitting diode served as a source of illumination at 0.95 micron wavelength. Two kinds of structures were found, with the photo-emf differently depending on the surface potential, namely "classical" ones with saturation in the range of strong inversion and "anomalous" ones with a sharp peak in the depletion (weak inversion) range. The spectral density of noise voltage $(V_{n,f})^{1/2}$ was also measured, at 200 Hz, as a function of a constant voltage at the field electrode on structures of both kinds. The results, particularly the frequency dependence of the photo-emf and the decrease of the maximum photo-emf with increasing rate of change of the voltage at the field electrode from positive to negative, indicate that the anodic oxide film plays a role in the recombination process and that localized diffusion occurs in "anomalous" structures. Figures 4; references 15: 13 Russian, 2 Western. [191-2415]

UDC 621.314.12:621.514.58

TRANSISTOR CONVERTERS WITH 10-YEAR LIFE UTILIZING WIDELY USED ELEMENTS

Kiev TEKHNIЧЕСКАЯ ELEKTRODINAMIKA in Russian No 6, Nov-Dec 82
(manuscript received 29 Jul 81) pp 41-44

ABUSERIDZE, A. V., VENEDIKTOV, Yu. P., LEONT'YEV, N. I. and MAZMANIDI, Ye. I.,
Sukhumi Physicotechnical Institute, GSSR Academy of Sciences

[Abstract] Of the components of self-contained power supplies, voltage converters have the shortest life. It is demonstrated that it is possible to lengthen drastically the life of transistor converters by combined use of the following: 1) Selecting optimal values for the load factors of elements; 2) Employing active parallel redundancy using fuses; 3) Employing special circuitry for standby redundancy; 4) Easing thermal conditions; and 5) Potting with sealing compounds. Several modifications of transistor converters have been designed. Elements of converters having a higher failure rate, i.e., transistors, have both active parallel redundancy and standby redundancy. A combination of fail-safe standby redundancy with the introduction of one additional transistor network resulted in a drastic increase in reliability. In one converter two redundant networks were connected to the six main transistor networks, each of which consists of a transistor and two fuses in its base and collector circuits. A single redundant capacitor is added to the three capacitors of the input filter. A fuse connected in series with this capacitor serves the function of switching from the circuit of an element which has failed because of short circuiting. Thermal conditions were eased by using for the purpose of removal of heat the surface of the redundant component not being used at a given instant. Potting with an epoxy compound reduces the influence of humidity and improves heat removal and uniform distribution of heat. The results of life tests are given, which demonstrate that the probability of failure-free operation of instruments and their elements as per the results of life tests is considerably higher than the calculated value. Life tests were conducted over a period of many years for seven DC-DC voltage converters for voltage of single numbers to dozens of volts. Two converters showed a life of 10 years, and their elements showed no signs of wear. Figures 1; tables 3; references: 3 Russian.
[131-8831]

HIGH VOLTAGE STABILIZATION IN CIRCUITS WITH PULSED TRANSFORMERS

Moscow ELEKTRICHESTVO in Russian No 3, Mar 83
(manuscript received 29 Jan 82) pp 44-47

ZHELTOV, K. A., Moscow

[Abstract] Among devices allowing stabilization of the amplitude and leading edge of a voltage are pulsed transformer-based devices containing controlled output dischargers which operate at the quasi-flat peak of the high voltage pulse. The secondary transformer circuit contains a nonlinear inductance, a choke with a ferromagnetic saturating core, usually of permalloy. The nonlinear inductance forms brief ignition pulses at intervals which are multiples of a half period of oscillation at the maximum output voltage, which means that with proper selection of parameters such circuits can achieve stabilized amplitude and leading edge of the high voltage associated with the moment of operation of the controlled discharge circuit. Two circuits for generating stable pulsed voltages are diagrammed and mathematically analyzed. Figures 3; references 8: 7 Russian, 1 Western.
[202-6508]

STUDY OF WAVE PROCESSES FOR RELAY PROTECTION OF SUPERHIGH TENSION LINES

Moscow ELEKTRICHESTVO in Russian No 3, Mar 83 (manuscript received 14 Jun 82)
pp 1-7

LACHUGIN, V. F., POPOV, I. N., candidates of technical sciences, SOKOLOVA, G.V., engineer (Scientific Research Institute of Electricity imeni Krzhizhanovskiy) and ZEYNALOV, A. D., engineer (Aberbaijan Scientific Research Institute of Electricity imeni Yes'man)

[Abstract] The results of studies of transient processes during short circuits and other disturbances on superhigh tension electric power transmission lines are analyzed in order to construct improved relay protection systems based on monitoring the information formed. The possibility of testing the direction of propagation of traveling waves is tested by analyzing processes in a symmetrical three phase line and in experimental studies in electric circuits. Single phase short circuit experiments were performed on 500 kV lines with longitudinal compensators at points located in different directions from the test point. Most complete satisfaction of the requirements for protection devices is achieved by monitoring information on damages formed by the transient process in contrast to monitoring of electrical characteristics at the line frequency. Selection of the damaged line with all types of short circuit is based on monitoring the direction of propagation of transient process waves in wave channels between conductors. The currents and voltages of transient process

waves propagating from the location of a short circuit in the frequency range from dc to several kilohertz over time intervals up to a few hundredths of microseconds decrease the variation of functioning of the protection as a function of circuit operating modes and transmission distance allowing significant improvements in speed. The monitoring device must be tuned to ignore disturbances not caused by short circuits. Figures 7; references 14: 12 Russian 2 Western.
[202-6508]

UDC 621.317.39:536.53:621.313.322-81-251:621.59

MEASURING SYSTEM FOR ROTATING CRYOSTATS

Moscow ELEKTROTEKHNIKA in Russian No 2, Feb 83 (manuscript received 29 Oct 82)
pp 46-48

GLEBOV, I. A., academician, USSR Academy of Sciences, DUL'NEV, G. N., doctor of technical sciences, professor, DANILEVICH, Ya. B., doctor of technical sciences, professor, ZHURAVLEV, G. S., candidate of technical sciences, and CHERNOPOL'SKIY, A. D., engineer, All-Union Scientific Research Institute of Electrical Machine Building (VNIIElektromash)

[Abstract] A system for measuring the temperature distribution in the rotor of the first pilot-production KTT 20 MW - 3000 rpm turbogenerator with superconductor field winding has been developed by the All-Union Scientific Research Institute of Electrical Machine Building, jointly with the Chair of Thermophysics at the Leningrad Institute of Precision Mechanics and Optics. Microcircuit instrument transducers are mounted on the rotor shaft, with Allen-Bradley 4.28-300 K thermistors as main primary probes and GaAs 4.2-100 K thermistors as auxiliary ones requiring individual calibration. There are also thermocouples installed: at the coolant inlet, along the rotor surface, at the coolant outlet, and with the flow meters in the heat exchangers. Each thermistor has two potential leads and two current leads at the output, for connection into a four-wire measuring system. The array of thermistors is connected to two 8-channel commutator switches driven by a timing generator. The equipment includes also a generator of stable current (operational amplifier with small temperature drift), a differential amplifier, range selector switches, a 20-60 kHz voltage-to-frequency converter, and an antenna (heavy copper wire with polyvinyl chloride insulation wrapped around a disk on the rotor shaft) on the transmitter side. On the receiver side is a horseshoe ferrite antenna, a detector with TTL logic, an amplifier-shaper, a frequency-to-voltage converter, and an "Elektronika S5-02" microcomputer with analog-to-digital conversion and synchronization. The accuracy of measurements by this system is ± 1 K in the 100-300 K range, ± 0.1 K in the 10-100 K range, and ± 0.01 K in the 4.28-10 K range. All thermistors draw a current of 30 μ A. The temperature of the coolant was measured during the process of cooling down the superconductor winding and during its cryostatization. Figures 6; references: 1 Russian.
[190-2415]

CALCULATION OF PARAMETERS OF DIVIDING ELEMENTS IN ARKAD'YEV-MARX GENERATOR

Moscow ELEKTROTEKHNIKA in Russian No 2, Feb 83 (manuscript received 13 Jul 82)
pp 48-49

KOZLOV, M. I., candidate of technical sciences, DZHUNOV, V. A., engineer,
GERSHENKROY, V. L., engineer, GOSHURENKO, V. I., engineer, and GORDIYENKO, N.I.,
engineer, Dneprodzerzhinsk Industrial Institute

[Abstract] The design of an Arkad'yev-Marx generator of pulse voltages is considered, taking into account the stray inductances and capacitances. An approximate expression is derived for the pulse duration as function of the generator parameters, with the generator feeding into a purely resistive load, namely $t_i = 3R_0 R_L C_0 / (2R_L + R_0 n)$ (R_0 - dividing resistance, n - number of equal sections, C_0 - capacitance of a section, R_L - load resistance). The derivation, by the method of input impedance, is based on an equivalent circuit of the discharge stage with resistive dividing elements and with switches and current supply shorted. The values thus calculated are subject to refinement by experiment. This was done for a generator feeding 40 kV pulses through respectively, $n = 6$ and $n = 8$ multiplying stages into a variable load resistance of 0.673-272.8 kohm. Figures 2; tables 1.
[190-2415]

X-RAY SENSITIVE RESISTS FOR SUBMICRON LITHOGRAPHY

Moscow MIKROELEKTRONIKA in Russian Vol 12, No 1, Jan-Feb 83
(manuscript received 14 Oct 81) pp 3-10

ALEKSANDROV, Yu. M., VALIYEV, K. A., VELIKOV, L. V., GLEBOVA, O. S.,
GRIBOV, B. S., DUSHENKOV, S. D., MOZZHUKHIN, D. D., PLESHIVTSEV, A. S.,
SELIVANOV, G. K. and YAKIMENKO, M. N., Institute of Physics, USSR Academy of
Sciences

[Abstract] A comparative study of x-ray sensitive polymer materials was made, for the purpose of selecting the most suitable ones as resist materials for x-ray lithography. Radiation from the FIAN S-60 synchrotron, with electron energies of several hundred MeV, was used as the source of soft x-rays in the 0.6-3.0 nm range of wavelengths. Four materials were tested as positive resists: PMMA (polymethyl methacrylate), MMA-MA copolymer (methyl methacrylate + methacrylic acid), GMA-BMA copolymer (glycidyl methacrylate + butyl methacrylate), CuMA-MA copolymer (copper methacrylate + methacrylic acid). Three materials were tested as negative resists: GMA-EA copolymer (glycidyl methacrylate + ethyl methacrylate), AAEMA-VE copolymer (acidic allyl ester of maleinic anhydride + vinyl ether) [expansion unknown], GMA-MMA copolymer (glycidyl methacrylate + methyl methacrylate). The film thickness was measured with an MII-4 microinterferometer, after development for 60 s, as a function of the radiation dose. The contrast was calculated as $\gamma = 1/\log (D_i/D_0)$ (D_i - dose corresponding to full development and D_0 - dose extrapolated linearly to initial thickness of positive resists, D_i - dose extrapolated linearly to full initial thickness and D_0 - dose corresponding to first appearance, i.e., zero thickness of negative resists). Prior to their deposition, the resist materials had been dissolved in appropriate organic solvents and passed through a 0.2-0.5 micron "Millipore" filter. On the basis of the results, MMA-MA and AAEMA-VE resists offer a high resolution (0.05 and 0.5 micron, respectively) along with sufficiently high sensitivity and contrast. Addition of copper (or an other heavy element) to the copolymer structure in increasing amounts has been found to sensitize increasingly the resist material, as demonstrated by MA and the CuMA-MA copolymer with a 1:10 ratio (2.6% Cu) and 1:5 ratio (5.2% Cu) of components. The authors thank A. M. Prokhorov for support and the accelerator operating staff for assisting with experiments. Figures 6; tables 2; references 12: 8 Russian, 4 Western (1 in translation).
[191-2415]

METHODS OF LOGICAL DESIGN AND COMPLEXITY EVALUATION FOR CIRCUITS WITH
COMPLEMENTARY MOS-TRANSISTORS

Moscow MIKROELEKTRONIKA in Russian Vol 12, No 1, Jan-Feb 83
(manuscript received 10 Dec 81) pp 42-47

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[Abstract] Mathematical modeling with logic, in the form of $G(V,E)$ graphs with sets of vertices V and edges E , is proposed for automatic design of CMOS circuits with LSI or VLSI. A field-effect MOS transistor with insulated gate and induced p- and n-channel is represented as a 3-pole device (source, drain, gate) with correspondingly three vertices and one edge. The edge represents the channel which connects source and drain (two vertices) and the gate vertex is labeled with a number or the logic-algebra function to be implemented by the gate. The mathematical model describes the circuit function, essentially the process of transmitting potentials 0,1 from input to output, which must be consistent physically and logically. The circuit complexity is defined as the number of edges (transistors) and the complexity of the logic algebra is equal to the minimum complexity of circuits implementing it. The latter is characterized by the Shannon function as upper bound. Methods of such modeling are demonstrated on a control circuit consisting of functional elements, each with several inputs and one output, also a contactor circuit and a relay-contactor circuit. Classical modeling and p- or n-modeling are compared in the case of a contactor circuit. Figures 5; references 7: 6 Russian, 1 Western.
[191-2415]

CALCULATION OF SPACE DISTRIBUTION OF ABSORBED ENERGY FOR ELECTRON-BEAM
LITHOGRAPHY

Moscow ELEKTRONIKA in Russian Vol 12, No 1, Jan-Feb 83
(manuscript received 15 Apr 82) pp 78-80

AKKERMANN, A. F. and GIBREKHTERMAN, A. L., Institute of High-Energy Physics

[Abstract] Simple control of the electron beam, together with the possibility of focusing the beam within 0.02-0.1 microns and attaining high energy densities in the resist, make electron-beam lithography eminently suitable for production of semiconductor circuits with superhigh packaging density. In this case picture size and shape will depend on the space distribution of absorbed energy, which is difficult to determine experimentally. A method of calculation has, therefore, been developed. It is based on the ETRIN program of computer simulation according to the Monte Carlo method. It was applied to a structure consisting of a 0.1-0.2 microns thick polystyrene (C_8H_8) film on a silicon substrate. Calculations were made for 3-10 keV electron beams 0.01-0.04

micron in radius, normally incident and distributed uniformly within $\pm 20\%$ over the spot area on the surface. A comparison with available data on other electron-resist materials (polyethylene terephthalate and polymethyl methacrylate) indicates that the energy distribution in those can be approximately estimated, on the basis of the results obtained with polystyrene, or calculated directly according to the same program. Figures 3; tables 1; references 5: 2 Russian, 3 Western.

[191-2415]

TRANSPORTATION

UDC 621.3.018.7

DYNAMIC PROCESSES IN ELECTROMAGNETS OF SUSPENSION SYSTEMS

Novocherkassk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ELEKTROMEKHANIKA
in Russian No 12, Dec 82 (manuscript received 28 Jan 82) pp 1432-1437

GRINCHENKOV, VALERIY PETROVICH, candidate of technical sciences, docent,
NIKITENKO, ALEKSANDR GRIGOR'YEVICH, candidate of technical sciences, docent,
and PAVLENKO, ALEKSANDR VALENTINOVICH, graduate student, Novocherkassk
Polytechnical Institute.

[Abstract] An electromagnetic suspension system is considered in which the width of the air gap between electromagnet and rail is held constant by means of automatic control. An algorithm is constructed for calculating the dynamic characteristics of such an electromagnet, i.e., its response to changes of the magnetizing current as a given function of time. Calculation of the magnetic field involves solution of a two-dimensional nonlinear differential equation describing the magnetic vector potential, assuming that the magnetic field is plane-parallel in the direction of the longitudinal axis. It is further assumed that the magnetic field is symmetric with respect to the vertical axis and that the magnetic flux remains within some rectangular boundary surrounding the II-core electromagnet. For numerical computation, the entire region of the magnetic field is subdivided into triangular elements and the magnetic vector potential in each is approximated with a linear combination of first-order interpolating functions. Flux linkages and thrust force are calculated for known magnetic field distribution and winding distribution in the magnetizing coil, with the current density in the magnetizing coil conductors assumed to reach its steady-state level exponentially. Calculations made for a 0.015 m wide air gap indicate that the electromagnet dynamics do not depend much on the geometry and the material of the suspension rail, an increase of the electrical conductivity of its material from 0 to 10^7

$(\text{ohm.m})^{-1}$ causing the rate of buildup of the vertical force to decrease by only 10%. Figures 5; references 2: 1 Russian, 1 Western.

[154-2415]

BASIC DESIGN OF LINEAR-INDUCTION TRACTION MOTORS FOR HIGH-SPEED GROUND TRANSPORTATION

Novocherkassk IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: ELEKTROMEKHANIKA
in Russian No 12, Dec 82 (manuscript received 5 Apr 78) pp 1414-1421

BOCHAROV, VASILIIY IVANOVICH, candidate of technical sciences, deputy director, and KUPRIANOV, YURIY VLADIMIROVICH, candidate of technical sciences, senior scientific research worker, both of All-Union Scientific Research Institute of Electric Locomotive Building, Novocherkassk, YEPIFANOV, ALEKSEY PAVLOVICH, candidate of technical sciences, junior research worker, and SOLOV'YEV, GERMAN IVANOVICH, candidate of technical sciences, acting docent, both of Leningrad Polytechnical Institute

[Abstract] The design of linear induction motors for high-speed ground transportation is analyzed, taking into consideration a large longitudinal end effect at speeds as high as 350-500 km/h and a wide (up to a few centimeters) air gap as well as limitations on the inductor length and width. Three target functions serve as performance criteria: maximum thrust F_{xm} and mechanical power P_{2m} per unit area of inductor core surface S_i and maximum electromechanical efficiency η_{em} . The two parameters to be optimized are also the most freely variable ones, namely the stator pole pitch τ and the electrical conductance $\gamma_2 d$ of the reaction rail. The problem is formulated as follows: to determine the most rational τ and $\gamma_2 d$ depending on the air gap width Δ , the inductor core width L_c , and the synchronous velocity v_s . The problem is solved by the method of ordered sifting, with the n -dimensional parallelepiped of parameter ranges subdivided into elementary n -dimensional parallelepipeds forming a grid. Sifting is done with respect to Δ , L_c , v_s , extrema of F_{xm}/S_i and P_{2m}/S_i only are sought with respect to τ and $\gamma_2 d$ only. The matrix of a planned 2-factorial experiment is set up, with factors coded into dimensionless quantities. Calculations based on this procedure have established that the critical slip, corresponding to maximum thrust, and the maximum efficiency do not vary much over the entire range of all parameters. Large critical slip and high maximum efficiency correspond to large values of τ , Δ , v_s . The slip corresponding to maximum mechanical power is almost equal to the critical slip. It therefore suffices to model mathematically, by way of polynomial approximation, only F_{xm}/S_i as a function of the variable parameters. Figures 6; tables 1; references 9: 3 Russian, 6 Western (1 in translation). [154-2415]

ELECTRIFICATION OF RAILWAY TRUNK LINES AND DEVELOPMENT OF ELECTRIC
LOCOMOTIVE PRODUCTION IN USSR

Novocherkassk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ELEKTROMEKHANIKA
in Russian No 12, Dec 82 (manuscript received 17 Aug 82) pp 1397-1404

KUROCHKA, ALEKSANDR LEONT'YEVICH, doctor of technical sciences, professor,
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[Abstract] Electrification of railroad trunk lines and production of electric locomotives in the Soviet Union is reviewed from a historical perspective, from the early stages of development through the 1921-68 period. Specific achievements within the framework of various Five-Year Plans are emphasized, the main contributors having been the Central Scientific Research Institute at the USSR All-Union Ministry of Railways, and the Novocherkassk Electric Locomotives Manufacturing Plant in operation since 1947. Basic technical and performance characteristics of the latest models of high-voltage locomotives, from VL 60 (since 1961) to VL 80-064 (since 1965), are listed. Pending complete electrification of long-distance trunk lines such as the 5500 km long Moscow-Baykal line and the 3500 km long Leningrad-Rostov-Tbilisi-Leninakan line are mentioned as some of the most formidable and significant goals made attainable by scientific and engineering progress. Growing demand and increased requirements necessitate further improvements in quality, efficiency, and economy of electric railway transportation. Tables 1; references: 7 Russian. [154-2415]

UDC 621.331:621.318.3.001.24

OPTIMIZATION OF ELECTRODYNAMIC SUSPENSION OF HIGH SPEED SURFACE TRANSPORT

Moscow ELEKTRICHESTVO in Russian No 3, Mar 83 (manuscript received 9 Nov 82)
pp 71-74

NAGORSKIY, V. D., MALAKHOV, V. I. and GOL'DSHTEYN, I. A., Moscow

[Abstract] The task of optimizing the electromagnet used in high speed electro-magnetically suspended transport systems, an endless thin electromagnetic circuit with predetermined flux moving over a conducting track structure, must be a multicriterion task, integrating planning of the suspension system as a whole. Two characteristic stages are distinguished in planning the electromagnet: 1) Planning of the magnet during stages of creation of experimental models; and 2) Planning of the electromagnet for a commercial, series produced car. In the first stage the optimization problem is solved as a multiple criterion problem, the final purpose of which is to produce optimal technological parameters of the magnet. In the second stage the optimization problem is solved as a problem of determinating the economically most effective version of the entire suspension system. These two stages of the problem are mathematically analyzed. The economic criterion suggested is the adjusted cost per

passenger kilometer using the concept of transported mass and transporting power. Optimization of the base version of an electromagnetically suspended car using the economic criterion reduced the adjusted cost per 40 ton car by 15 to 20%. References: 7 Russian.
[202-6508]

TRANSIENT PROCESS IN ELECTRICAL BURSTING OF CONDUCTORS

Kiev TEKHNIЧЕСКАЯ ELEKTRODINAMIKA in Russian No 6, Nov-Dec 82
(manuscript received 23 Jul 81) pp 15-21

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[Abstract] Electric bursting of conductors in condensed media is used to produce powerful pressure pulses in new processes for treatment of materials. Transient processes in the discharging circuit are involved in the formation of pressure waves resulting from conversion of the energy of the electrical burst. Identification of the transient process is difficult when the resistance changes suddenly during a single half-cycle of the discharging current, largely because of non-uniqueness of the functional dependence of resistance on the electrical characteristics. Calculations describing the transient process are performed on the basis of a thermal mechanism for bursting of the conductor, in the case of underwater electrical bursting. With the same calculation scheme it is possible to use another key variable instead of the temperature, whose relationship to resistance is the same as that given here. For example, the specific energy released in the conductor can be used in the case of magnetohydrodynamic instabilities. For the case of the thermal mechanism, the system of equations describing the dynamics of adiabatic heating of the conductor includes an equation for the RLC discharging network and a heat balance equation, and this system is closed by an equation defining the relationship between the resistivity and temperature. Here the behavior of electrical conductivity in the vicinity of the critical temperature is similar to the behavior of a certain ordering parameter in the theory of phase transitions of the second kind. At the time when the current in the discharging circuit reaches its first maximum, the temperature of the conductor reaches the melting point. This experimentally established fact makes it possible to obtain an approximate solution to the initial set of equations. It is demonstrated that with a reduction in the conductor's cross section the time it takes for the current in the discharging circuit to reach the first maximum is reduced. It is shown that this time, τ_0 , can be identified with the beginning of a sudden deviation of the current curve from the short-circuiting curve, or with the first current maximum. A solution is obtained which describes the first phase of the initial stage of bursting of the conductor. The description is completed on the basis of the fact that at the moment of bursting the

conductor's resistance has a distinctly pronounced maximum. An expression is found for the current in the discharging circuit at the moment of bursting and for the moment of time at which the conductor bursts. Good agreement with experimental data was found for the results of calculations of characteristic parameters arrived at by using the expressions derived. References:

10 Russian.

[131-8831]

UDC 061.4:621.3."1982"

OVERVIEW OF 'ELEKTRO-82' INTERNATIONAL EXHIBITION

Moscow ELEKTROTEKHNIKA in Russian No 2, Feb 83 pp 2-6

DZHANOYAN, A. S., chief of Technical Management, Ministry of Electrotechnical Industry

[Abstract] In the Soviet pavilion of the "Elektro-82" International Exhibition of electrical equipment and electrical transmission lines held in Moscow 13-27 July 1982 more than 2000 items developed and produced by 256 Soviet enterprises and institutions were shown. Most noteworthy among them were a 1000 MW - 1500 rpm turbogenerator, Elgas circuit breakers, 110-500 kV oil-filled power cables, 0.4-3.5 kW lamps, electrothermal equipment and solar radiation integrators for agriculture, "Meteor-Priroda" weather satellite with V-7 control computer complex, production mechanizing and automating equipment with direct digital control used for manufacture of wound stators for electric motors ranging from small to 100 kW, automatic manipulators for PR-25 industrial robots with transistor-controlled induction-motor drive, SM-600 and "Luch-51" machine tools for drilling printed-circuit boards, UPS welding machine for parts of low-carbon and low-alloy steels, "Yenisey" plasma-air machine for cutting metal blanks of various shapes, prototype of ULN 1.2 kV laser-beam machine for heat treatment and fabrication, YaRE-2201 6-10 kV universal protective equipment, BU-3609 and BTU-3601 thyristor converters, ETU-3601 thyristor-controlled and EShIR-1 transistor-controlled electric motor drives, and in the field of medicine the SRT-1000 computerized tomograph for prophylactic diagnosis.

[190-2415]

UDC 621.365.001.2::061.4:621.3."1982"

SOME TRENDS IN ELECTROTHERMY DEVELOPMENT AS REVEALED IN 'ELEKTRO-82' EXHIBITION

Moscow ELEKTROTEKHNIKA in Russian No 2, Feb 83 (manuscript received 29 Oct 82) pp 7-10

BORODACHEV, A. S., candidate of technical sciences, and AL'TGAUZEN, A. P., candidate of technical sciences, All-Union Scientific Research Institute of Electrothermy (ETO)

[Abstract] Electrothermal equipment shown at the "Elektro-82" exhibition by manufacturers from various capitalist countries reveals several trends in the

development of such equipment. Foremost among them is increased automation with the aid of microprocessor-microcomputer systems and gas-discharge indicators for digital information display. Interesting innovations include control of superhigh-power steelmaking electric-arc furnaces, complex protection of steelmaking induction furnaces, performance maintenance of mobile induction furnaces, programming of pressure treatment in induction furnaces, control of electric furnaces for pulling of silicon single crystals by the Czochralski method, control of heating and movement of ingots in resistance furnaces, and programming of kitchen ranges. Other trends are found in refinement of measuring and recording instruments such as precision pyrometers and contactless thermoscopes, refinement of power supplies, standardization of components, better design of equipment for most economical use of energy and materials (noteworthy examples being recirculation of exhaust gases for heating, lining of furnace walls with fiber-reinforced composites, coating of heater surfaces with silicon oxynitride), adaptation of induction furnaces for steel smelting, adaptation of resistance furnaces for various heat treatment processes, split construction of ore-reducing furnaces with independent rotation of upper part and lower part, improvement of existing models and addition of new models of furnaces and crucibles for production of single crystals by various technologies, built-in heater plates in wire-enameling furnaces, specialty low-temperature furnaces, and continuous improvement of electric household heating appliances. No significant developments have been made recently in electric-arc steelmaking furnaces. References: 5 Russian. [190-2415]

ALL-UNION SCIENTIFIC-TECHNICAL CONFERENCE ON DYNAMIC OPERATING MODES OF ELECTRICAL MACHINES AND DRIVES

Novocherkassk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ELEKTROMEKHANIKA
in Russian No 12, Dec 82 pp 1478-1479

BESPALOV, Ya. V., candidate of technical sciences, docent at Moscow Power Engineering Institute

[Abstract] An All-Union Scientific-Technical Conference on "dynamic operating modes of electrical machines and drives" was held 12-15 October 1982 in Groznyy (capital of Checheno-Ingushskaya ASSR), organized jointly by the USSR and RSFSR Ministries of Higher and Secondary Specialized Education, the Moscow Power Engineering Institute and the Groznyy Petroleum Institute imeni Academician M. D. Millionshchikov. The conference was conducted in four sections: 1) Dynamic modes of synchronous machines; 2) Transient processes in synchronous machines; 3) Dynamic modes of commutator machines; and 4) Dynamics of electrical drives in mining and petroleum industries. The conference was attended by representatives of 55 higher educational institutions and 15 scientific research and design institutes, large scientific-industrial associations, and industrial plants located in 43 cities of the Soviet Union. The topics of 162 presentations and discussions were: new models and types of electrical machines,

including linear motors, optimal control, methods of analysis and computer-aided analysis, frequent switching under variable and stochastic loads, heating during transients, electromechanical transients in turbomachines, starting and self-starting of synchronous motors, stability of d.c. machines and field suppression during transients. A group of papers dealt with the dynamics of special-purpose electrical machines for mining and oil drilling, methods of improving their dynamic characteristics, and optimal automatic control on a microcomputer base. The papers presented at the conference covered the results of theoretical and experimental studies made during the past 3-4 years. It was recommended that another conference be held in 1986.
[154-2415]

CSO: 1860

- END -